

Detection of Active Deformation Areas based on Sentinel-1 imagery. An efficient, fast and flexible implementation

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From Imagery to Digital Reality: ERS & Photogrammetry.
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CTTC^R Context: the (H2020) MOMIT project

- Development and demonstration of new uses of remote sensing technologies for railway infrastructures monitoring.
- For maintenance and prevention processes within the infrastructure management lifecycle.
- Multi-sensor, multi-scale data (RPAS, satellite...).



MOMIT
MULTI-SCALE OBSERVATION
AND MONITORING OF RAILWAY
INFRASTRUCTURE THREATS





CTTC^R Context: the (H2020) MOMIT project (2)

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NEAT S.r.l. - Italy



Rete Ferroviaria Italiana - Italy

TERABEE
Terabee S.A.S. - France



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University of Alicante - Spain



CTTC^R Context: the (H2020) MOMIT project (3)

6 demonstrators

- Ground movements nearby the infrastructure.
- Hydraulic activities nearby the track.
- Global supervision for natural hazards.
- Electrical system monitoring.
- Civil engineering structures monitoring.
- Safety monitoring.



CTTC^R The ADAfinder application

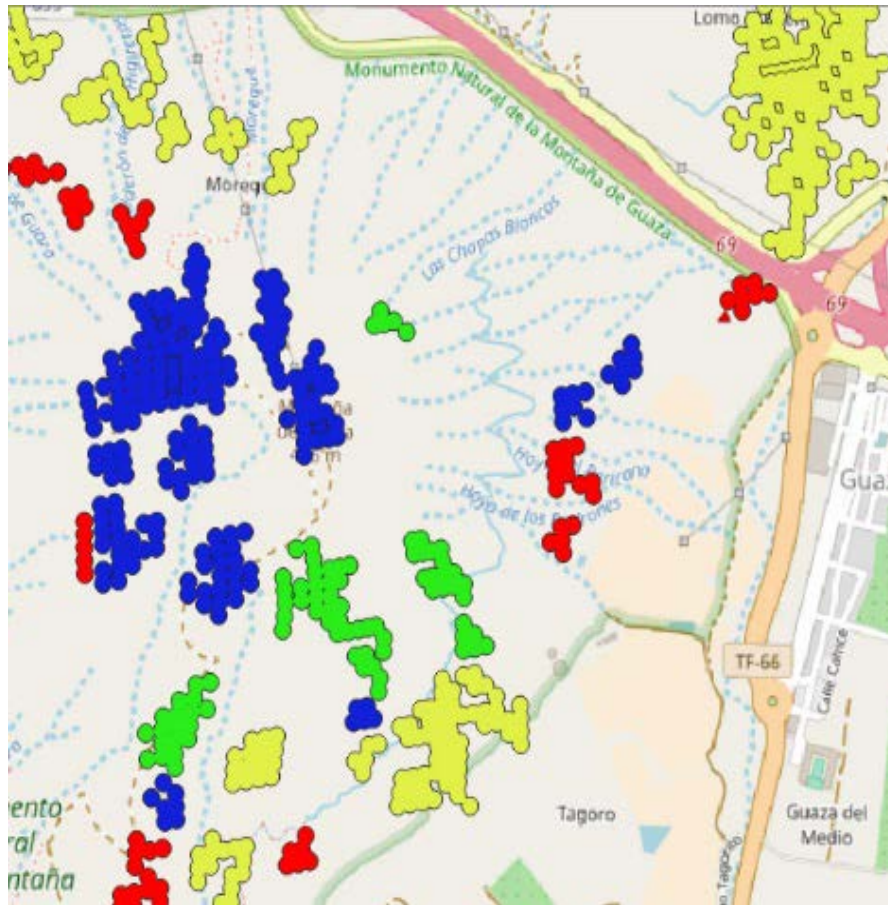
- Detection and updating of Active Deformation Areas using Sentinel-1 imagery (Point Scatterers).
- A methodology already exists, which is described here:



Barra, A. et al, 2017. "A methodology to detect and update active deformation areas based on Sentinel-1 SAR images." Remote Sensing, 9, no. 10: 1002.



CTTC^R The ADAfinder application (2)



Input

Point scatterers derived from Sentinel-1 imagery (coordinates + deformation time series).

Output

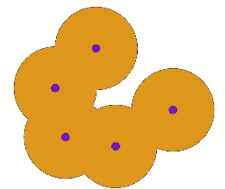
ADA map, plus a quality assessment (4 levels of certainty).



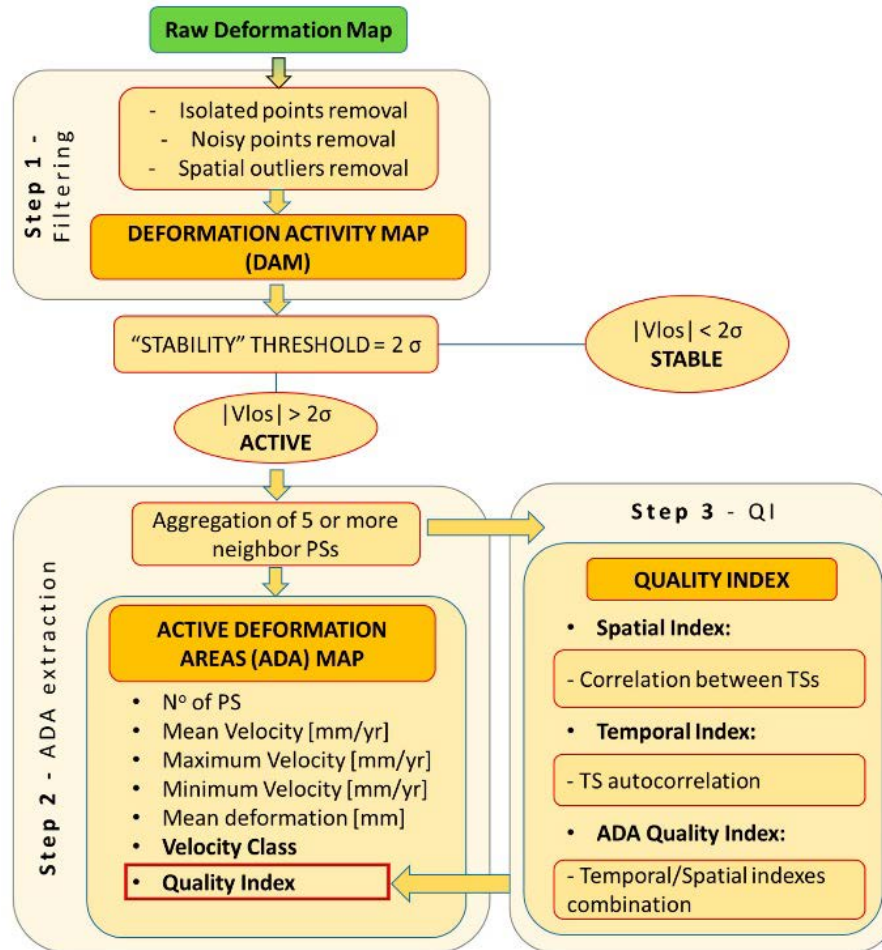
CTTC^R The ADAfinder application (3)

Goals

- **Automation** of the aforementioned methodology.
- Providing a **fast, efficient** and **flexible** solution, able to deal with the unavoidable variation always present in input data files (ESRI shapefiles only).
- Avoiding human (GIS-based) operational mistakes, reducing noticeably the time and expertise required to find the ADAs.



Source: Barra, A. et al, 2017



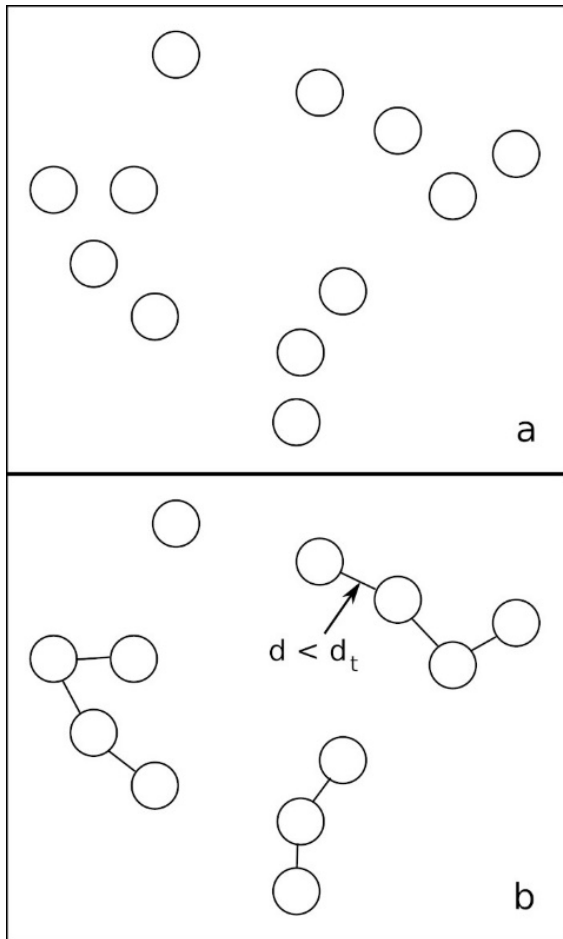


CTTC^R The algorithm in a nutshell (2)

- Simple from the mathematical standpoint.
- But pretty costly ($O(n^2)$) in computational terms if a naïve solution is implemented to identify:
 - **Isolated** points,
 - Spatial outliers (points with too few **neighbors**) and
 - **Groups** of points that are **close enough**.
- The **clustering algorithm** is crucial.



CTTC^R The clustering algorithm



The algorithm interprets the input points as the **vertices** in a graph.

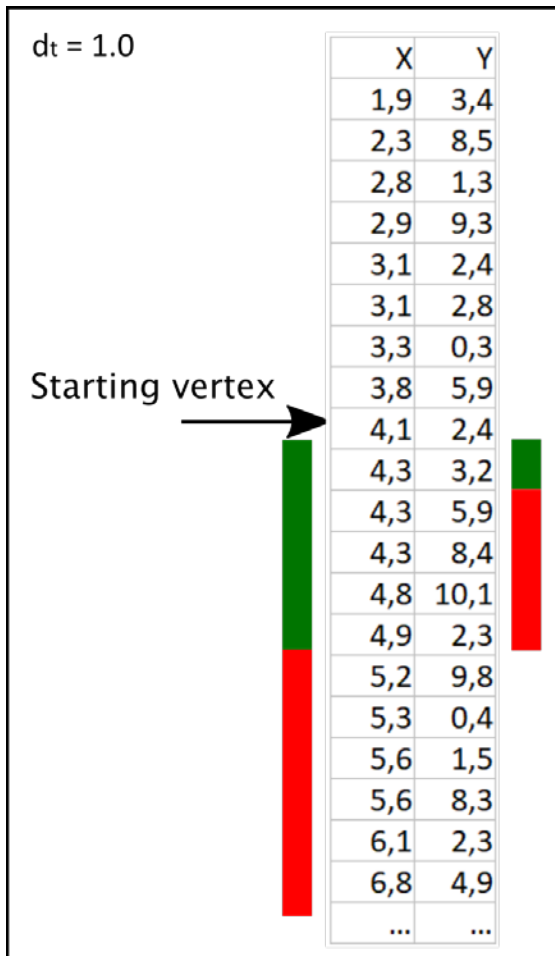
There exist **no arcs**, however.

When the distance d between two points is less than some threshold d_t , then the algorithm interprets that an arc exists between these. So we've got a graph.

Then, the algorithm look for **connected components** using a classic **DFS** strategy.



CTTC^R The clustering algorithm (2)



Sorting data is crucial, since we have *virtual* arcs. The sort criteria are the X (1st) and Y (2nd) coordinates.

When looking for a connected component, the first point beyond the d_t distance stops the search.

No need to check the distances between all couples of points! From $O(n^2)$ to $O(n)$.



- PSs are input using **ESRI shapefiles**.
- There is a set of **required** attributes (.dbf file).
- The **positions** of these attributes may **change** when using shapefiles coming from diverse projects.

- Simple *read-map* files are used to show where to find the attributes.

Flexibility.

POSITION_X	=	5
POSITION_Y	=	6
POSITION_VELOCITY	=	9
POSITION_TIME_SERIES	=	11
N_VALUES_TIME_SERIES	=	50



CTTC^R Everywhere. In every possible way

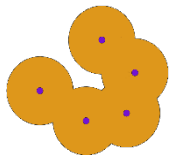
- **C++. Qt5. Portable** (Windows / Linux).
- Available in **three incarnations:**



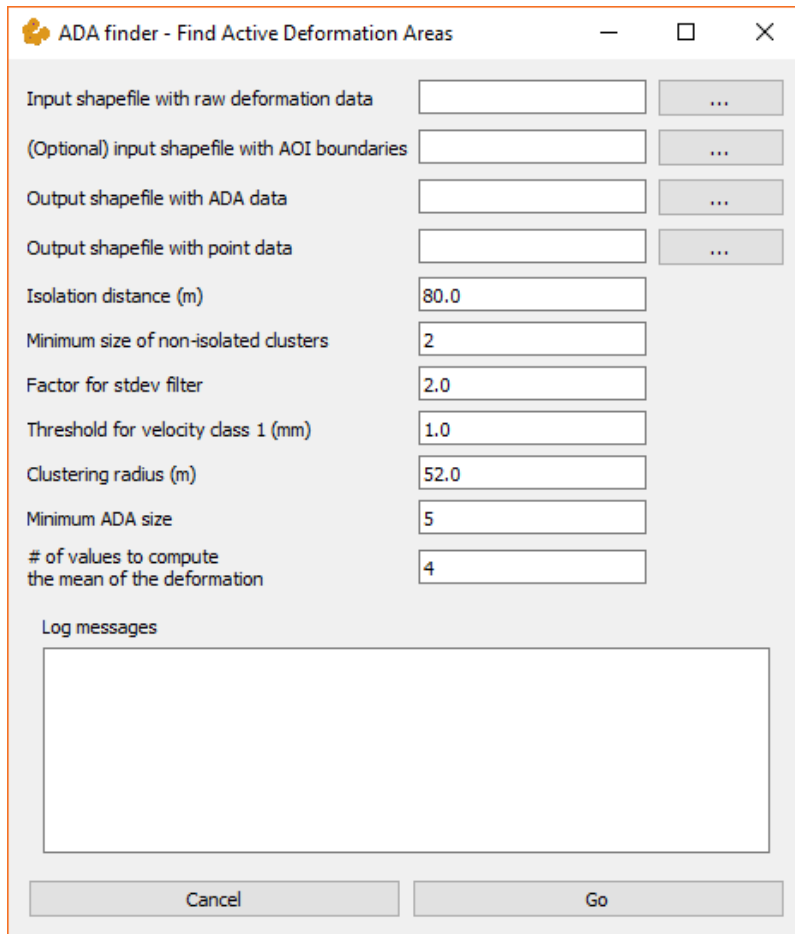
Library. Embed ADAfinder's logic in other applications.



Command line application. Run in batch-oriented production environments.



GUI application. Let the expert process data easily.



ADA finder - Find Active Deformation Areas

Input shapefile with raw deformation data ...

(Optional) input shapefile with AOI boundaries ...

Output shapefile with ADA data ...

Output shapefile with point data ...

Isolation distance (m)

Minimum size of non-isolated clusters

Factor for stdev filter

Threshold for velocity class 1 (mm)

Clustering radius (m)

Minimum ADA size

of values to compute the mean of the deformation

Log messages

Cancel Go

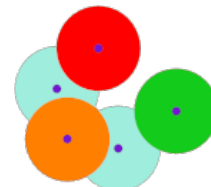
- Mean performance improvement **10x**.
- ~1 million points / about 3' (regular i5 laptop with 8Gb RAM and magnetic -not SSD- disk, no GPU, no parallelization).
- Regularly used at CTTC in production tasks.



CTTC^R Conclusions & outlook

- Fast, flexible, portable application automating a well-tested procedure. Integrable in GIS tools.
- Avoids error-prone manual operation, boosting operator's performance 10x. Much more room for experimenting.
- Available as a library, command line or GUI apps.
- More to come in the context of the MOMIT project:

los2hv



ADAclassifier



CTTC^R

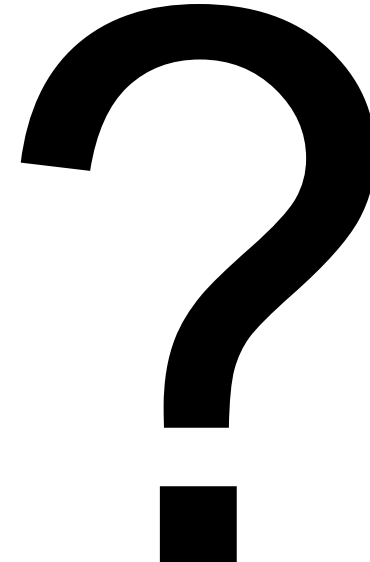
Thank you very much!

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